Active Project (2015 - 2017)

High Fidelity Tool for Turbulent Combustion in Liquid Launch Propulsion Systems Based on Spray-Flamelet Methodology, Phase II Project

SBIR/STTR Programs | Space Technology Mission Directorate (STMD)

ABSTRACT

The innovation proposed here is a high-performance, high-fidelity simulation capability for simulating liquid rocket spray combustion based on a novel spray-flamelet methodology which will be integrated into Loci-STREAM which is a CFD solver developed by the proposing personnel under funding from NASA over the last several years. A new spray-flamelet formulation will be incorporated into Loci-STREAM. The particular advantages of this formulation are (i) its consistency with the single-phase flamelet-formulation (already available in Loci-STREAM), (ii) its formulation in mixture-fraction space, overcoming the non-uniqueness of the classical mixture-fraction parameterization, and (iii) its applicability to finite Stokes-number, thereby accounting for particle evaporation, slip-velocity, and poly-dispersed spray-phase. The flamelet methodology already available in Loci-STREAM – in conjunction with Hybrid RANS-LES (HRLES) methodology – has facilitated an order of magnitude improvement in simulation turnaround times for NASA applications involving complex physics in 3D geometries. This project is aimed at extending this flamelet methodology to spray combustion resulting in a state-of-the-art design and analysis tool to enable accurate, fast and robust simulations of multiphase combustion in liquid rocket engines (involving liquid propellants such as LOX and LH2/LCH4/RP-1/RP-2), combustion stability analysis, etc. which constitute critical components of NASA's upper stage launch propulsion systems.

ANTICIPATED BENEFITS

To NASA funded missions:

Potential NASA Commercial Applications: The outcome of Phase 2 activities will be a powerful CFD-based design and analysis tool for propulsion engines of relevance to NASA. This tool is envisioned to be useful for full rocket engine simulations, injector design, etc. Specific applications at NASA of this

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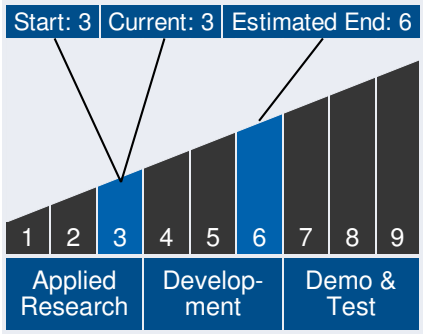
Technology Maturity



Management Team

Program Executives:

- Joseph Grant
- Laguduva Kubendran

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capability include: (a) high-fidelity simulations of nano-launcher upper stage propulsion systems, (b) design improvements of injectors of J-2X and RS-68 engines as well as potential novel designs to be developed for NASA's proposed heavy lift vehicle, (c) modeling of multi-element injectors coupled with fuel and oxidizer feedlines and manifolds, (d) prediction of stability and stability margins, etc.

To the commercial space industry:

Potential Non-NASA Commercial Applications: The computational tool resulting from this project will have wide-ranging commercial applications. The Hybrid RANS-LES methodology can be used for a wide variety of engineering applications involving unsteady turbulent flows. The reacting flow capability can be used for simulating combusting flows in various industrial applications, such as gas turbine engines, diesel engines, etc. The real-fluids methodology can be used in a large number of industrial flow situations involving both chemically inert and reacting flows. With additions of multi-phase spray combustion modeling capability, the applicability of this tool can be further broadened.

Management Team *(cont.)*

Program Manager:
- Carlos Torrez

Principal Investigator:
- Siddharth Thakur

Technology Areas

Primary Technology Area:
Launch Propulsion Systems (TA 1)
- Liquid Rocket Propulsion Systems (TA 1.2)
  - Fundamental Liquid Propulsion Technologies (TA 1.2.6)
    - Advanced Design and Analysis Tools (TA 1.2.6.1)

Secondary Technology Area:
Launch Propulsion Systems (TA 1)
- Liquid Rocket Propulsion Systems (TA 1.2)
  - RP/LOX Based (TA 1.2.2)

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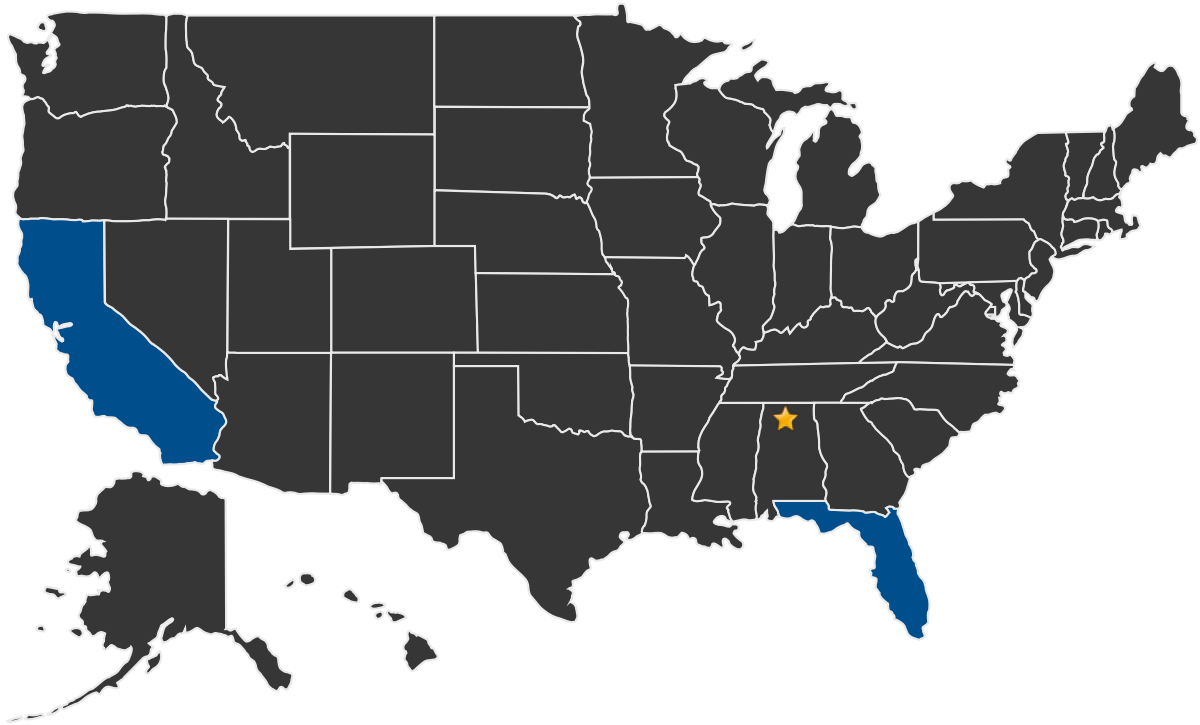
U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Marshall Space Flight Center

Other Organizations Performing Work:

- Stanford University
- Streamline Numerics, Inc. (Gainesville, FL)

PROJECT LIBRARY

Presentations

- Briefing Chart
  - (http://techport.nasa.gov:80/file/18037)

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DETAILS FOR TECHNOLOGY 1

Technology Title

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